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TECHNICAL REPORT

colour
inside

Display lighting unit –
Part 1-4: Glass light guide plate

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IEC TR 62595-1-4, which is a Technical Report, has been prepared by IEC technical committee 110: Electronic displays.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
110/1174/DTR	110/1200/RVDTR

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62595 series, published under the general title *Display lighting unit*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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DISPLAY LIGHTING UNIT –

Part 1-4: Glass light guide plate

1 Scope

This part of IEC 62595, which is a Technical Report, provides general information for judging the necessity of future standardization of glass light guide plates for display lighting units, which include backlight units for transmissive displays such as LCDs, and frontlight units for reflective displays.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62595-1-2:2016, *Display lighting unit – Part 1-2: Terminology and letter symbols*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions given in IEC 62595-1-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
glass light guide plate
GLGP
light guide plate whose optically transparent medium is made of glass material

Note 1 to entry: See IEC 62595-1-2:2016, 3.3.1. A GLGP includes optical elements for light guide plates, such as diffusion patterns, in addition to a glass sheet for light guide plates.

3.2 Abbreviated terms

BLU	backlight unit
CTE	coefficient of thermal expansion
DLU	display lighting unit
FLU	front lighting unit
FPC	flexible printed circuits
GLGP	glass light guide plate
HDR	high dynamic range
LC	liquid crystal

LCD	liquid crystal display
LED	light emitting diode
LGP	light guide plate
MCPCB	metal core printed circuit board
MS	methyl-methacrylate styrene copolymer
PDLC	polymer dispersed liquid crystal
PMMA	polymethyl methacrylate
S/N	signal/noise ratio

4 Overview

4.1 General

Glass light guide plate (GLGP) enables distinctive display product features such as thinner, lighter, larger and narrower bezel design with several additional considerations of material properties and stabilities compared to conventional polymer light guide plate. This document intends to investigate display product features enabled by GLGP and to identify possible future standardization.

4.2 Light guide plate technologies and its typical materials

An LGP is a component of an edge-lit backlight unit (BLU) as shown in Figure 1 and in IEC 62595-1-2:2016, Annex A. This edge-lit BLU has been widely used for thin LCDs. In the BLU, the light emitted from LEDs positioned in close proximity to the edges of the LGP is optically coupled into the LGP to illuminate an LC device. Figure 2 shows the schematics of the cross-section view of the LGP. The light from the LEDs propagates in the LGP by means of total internal reflection, and the patterned reflection dots at the surface disrupt the total internal reflection to couple out light, resulting in uniform light output for surface illumination.

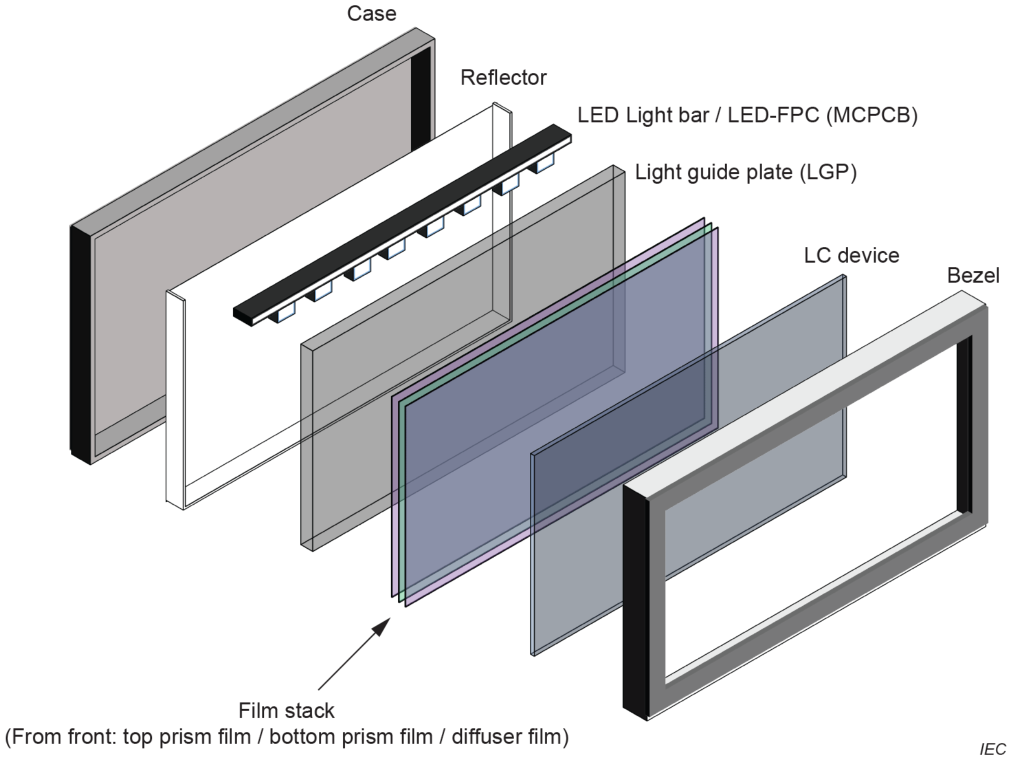

Figure 1 – Structure of edge-lit BLU and LGP

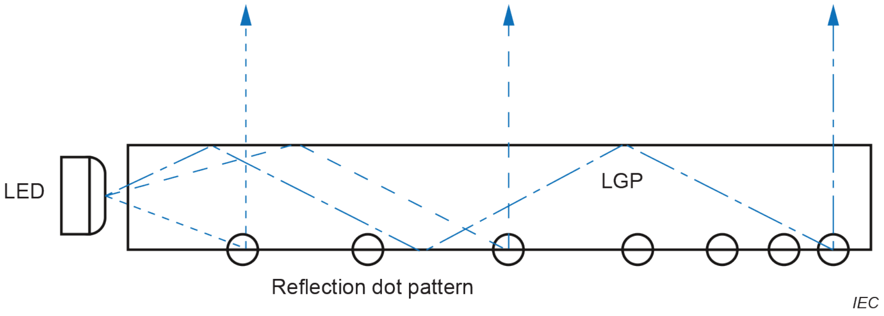

Figure 2 – Light propagation in an LGP

Generally, polymer materials, such as polymethyl methacrylate (PMMA) and methyl-methacrylate styrene copolymer (MS), have been applied for the LGP due to their excellent optical properties. However, the polymer LGP has apparent disadvantages: lower stiffness, deformation by humidity, higher thermal expansion, and lower chemical and thermal stability (see Table 1). Because of its lower stiffness, the polymer LGP is difficult to apply for extra-large size displays, that is, larger than 65 inches with ultra-thin design less than 5 mm. Easier deformation by humidity and thermal expansion result in the limitation of TV sets design to keep the optical clearance between LEDs and LGPs. In addition, the thermally unstable nature is not suitable for future high power LEDs that also generate more heat and introduce higher temperature; it potentially limits the brightness improvement of the BLU [10][1].

Table 1 – Comparison between polymers and glasses for LGP

	Polymer	**Glass**
Young's modulus (GPa)	Low (~5)	High (≈70)
Thermal conductivity (W/m/K)	Low (≈0,2)	High (≈1,1)
Thermal expansion ($\times 10^{-7}$ 1/K)	High (> 400)	Low (< 100)
Water/humidity absorption (vol %)	High (< 0,1)	None
Flammability	Yes	No

4.3 Advantages of and issues with GLGP

Glass materials have been gathering much attention these days as the candidates for novel LGP materials because they have better chemical durability, thermal stability, and mechanical properties in comparison with polymers. GLGPs have been already mass produced [1] to [3], and GLGP installed LCD TVs and monitors have been on the market [4], [5].

Although anticipation has increased, various major hurdles have to be overcome before GLGPs become popular. One is the facility asset: existing production lines, supply chains of BLUs are basically optimized to use polymer LGPs, and are not easy to convert to use GLGPs. Another big issue is the lack of appropriate information: most of the documentation related to the LGP was prepared with the use of polymers in mind, therefore the appropriate information is difficult to reach. Evaluation methods are also designed with the use of polymers in mind, hence some of these, such as optical properties, mechanical and environmental properties, seem inappropriate to the glass. If the correct recognition of the difference between these two materials is not sufficient, biased knowledge and experiences of the polymer LGP can prevent the adoption of the glass materials. In addition, the current structure explained in Figure 1 would be based on polymer LGPs, and for GLGPs a new structure might be applied according to the feature of the GLGP. The current standards for BLUs need to be checked considering whether they are based on only polymer LGPs or not.

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[1] Numbers in square brackets refer to the Bibliography.

As an additional point of view, compared with polymer LGPs, GLGPs may be suitable not only for the BLUs mentioned above but also for other DLUs such as FLUs, transparent LCDs, and so on, which seems attractive for the future. According to this situation, this document summarizes the basic information of GLGPs and the desirable characters for GLGP application, in order to discuss the necessity of revising the current BLU standards [6] to [9] and proposing new standards.

5 Optical characteristics

5.1 Factors affecting optical characteristics of GLGPs

The main function of the GLGP is the light propagation from the incident edge to the output surface, and both the radiant or luminous flux and chromaticity are expected to become uniform in the whole output surface. Applying the reflection tapes around one or three side (non-incident) surfaces of the GLGP can increase the luminance and uniformity. Uniformity of the illuminant power and chromaticity depend on the optical absorption, scattering loss during the propagation, and loss of the LED coupling at the incident edge.

1) Optical absorption: the absorption of the glass material itself is the major factor to determine the optical performance of the GLGP.
2) Scattering loss: the GLGP generally uses ink-based light extraction. It uses scattering as its mechanism to control light. This scattering by the reflection dot pattern has spectral and spatial dispersion, thus it also causes the similar effect of optical absorption. This effect is not unique to GLGP, but the GLGP is expected to use a thinner thickness compared to polymer LGPs, such as less than 3 mm in thickness, so the light hits the ink more often than on a thicker LGP, and it amplifies the ink's deleterious effects.
3) Loss of the LED coupling: from the viewpoint of GLGPs, the loss at the LED coupling is affected by the distance between the LED and the LGP and the edge surface condition of the GLGP such as edge straightness, edge surface waviness, incident area width, chamfering shape and roughness.

5.2 Optical absorption of the glass materials for LGPs

The optical path length of the LGP in LCD TVs is longer than several tens of centimetres, whereas that in general usage is several millimetres at the most. Therefore, lower optical absorption, that is, higher internal transmittance, is mandatory for the glass for LGPs. These distinguishing characteristics are reported in the references [10] and [11]. Figure 3 shows examples of internal transmittance spectra of the commercial glass for LGPs. The spectra of MS, PMMA and conventional extra clear glass for solar cells are shown as a reference. Note that the optical path length of the spectra in Figure 3 is 50 cm, in contrast with the length of the normal spectra which is 1 cm at the most. As shown in Figure 3, the glass for LGPs showed significantly higher internal transmittance than conventional glasses; the internal transmittance of the glass for LGPs is higher than 80 % even if the optical path length is as long as 50 cm.